

# ***Testing Update on 20 and 25-Ah Lithium Ion cells***

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## ***Topics***

- **Introduction**
- **20-Ah Cell, Design I**
  - **Design**
  - **Test Results, Cell cycling at various temperatures and storage**
- **25-Ah Cell, Design II**
  - **Design**
  - **Test Results, various temperatures, cell cycling and LEO cycling**
- **Conclusions**

## ***Introduction***

- **Eagle-Picher Energy Products has worked on lithium ion batteries for approximately 8 years**
- **During that period EPEPC developed and delivered several cell sizes on a program funded by the USAF and Canadian DND**
- **Designs are wound cylindrical cells from 7 to 40-Ah**
- **Most cells delivered were approximately 25-Ah due to requirements of Mars missions**
- **Several iterations of cells were manufactured and delivered for evaluation**
- **The first design was 20-Ah, Design I, and the second was a 25-Ah, Design II**

## ***Introduction***

- Deliveries related to the program were:**
  - 10, 20-Ah cells to JPL 05/97**
  - 12, 7-Ah cells to JPL 05/98**
  - 12, 25-Ah cells to JPL 05/98**
  - 10, 37.5-Ah cells to Phillips 05/98**
  - 10, 25-Ah cells to LMA 08/98**
  - 30, 25-Ah cells to JPL 09/98**

## ***Introduction***

- **Cells have been under test at JPL for over 5 years**
- **All results presented were supplied by JPL**
- **No events of significance to report**
- **The “25-Ah” cell designs evolved over time**
- **Increased rate capability; tabbing issues**
- **Increased low temperature performance;  
electrolyte**

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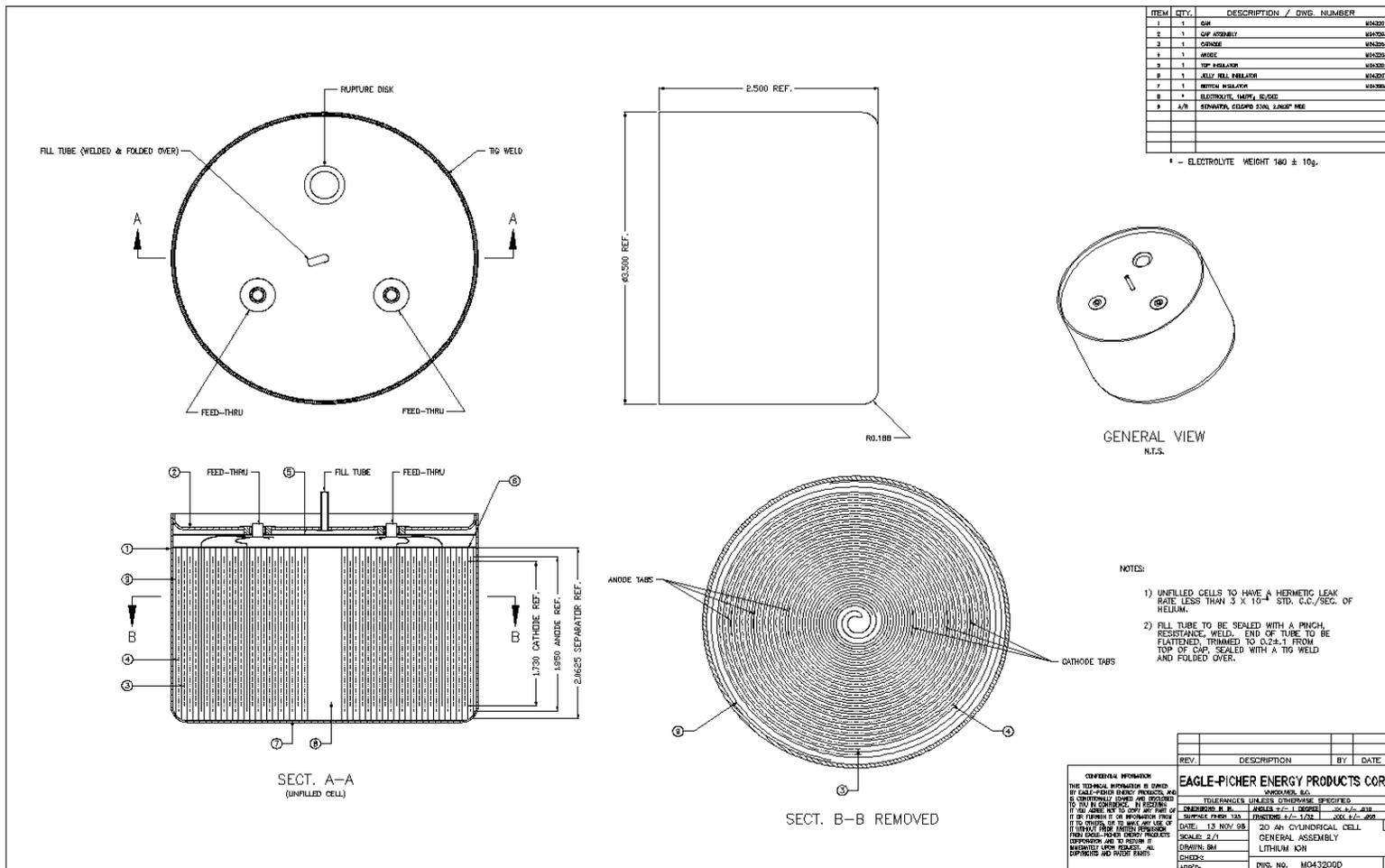
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# ***Design Features - Design I***

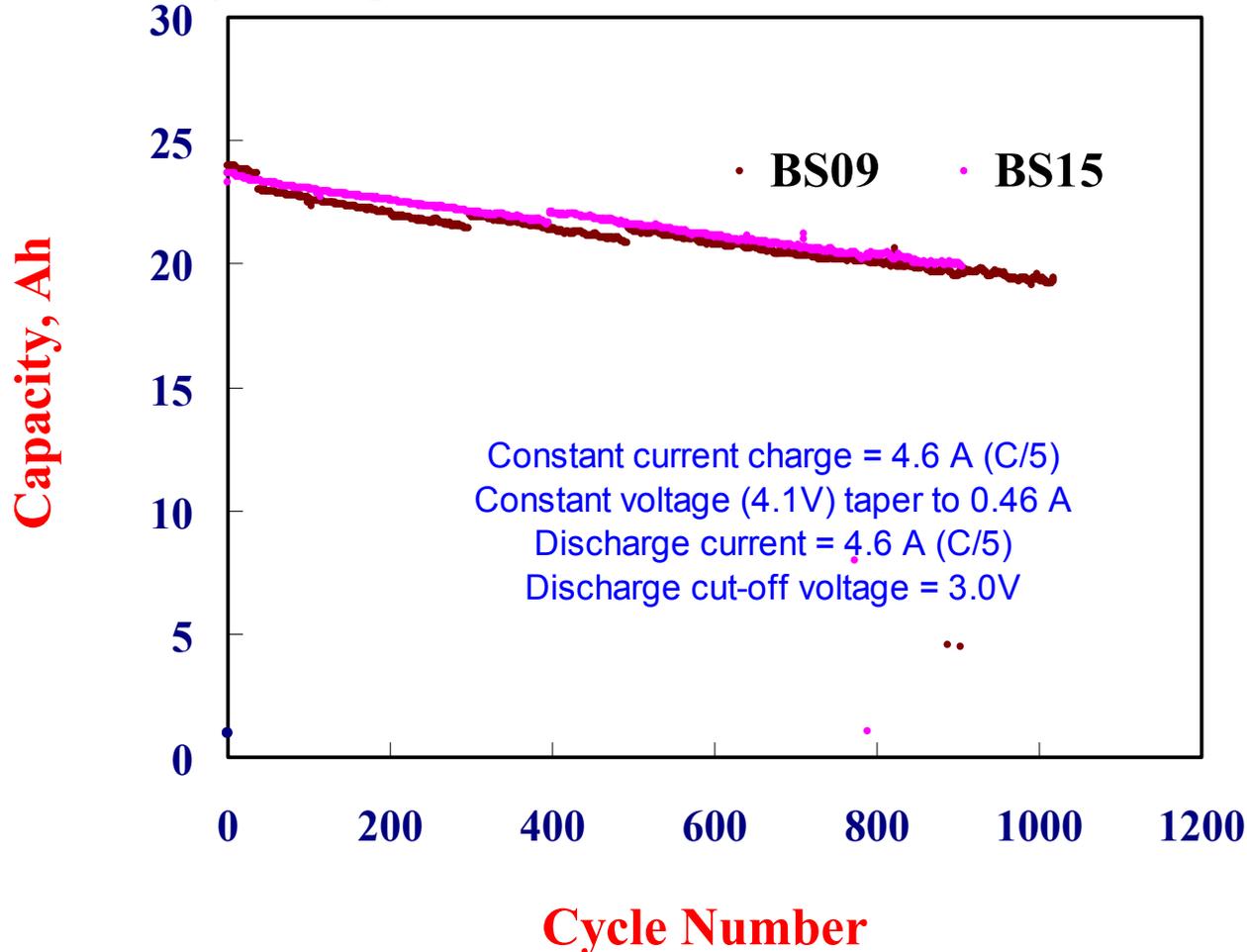
- o Drawn Can - SS304**  
**3.50" diameter x 2.50" x 0.19"**
- o Standard Penetrations**  
**TA-23, 0.125" Mo**  
**Fill Tube, Rupture disc 235 psi**
- o Positive electrode, 1300 x 4.40 x 0.017 cm (LiCoO<sub>2</sub>)**
- o Negative electrode, 1330 x 4.70 x 0.011 cm (Graphite)**
- o Delivered May 1997**



## Cell Design - Design I



## Cycling at 23°C - C/5, 100% DOD



- Capacity fade rate : 0.019% per cycle.

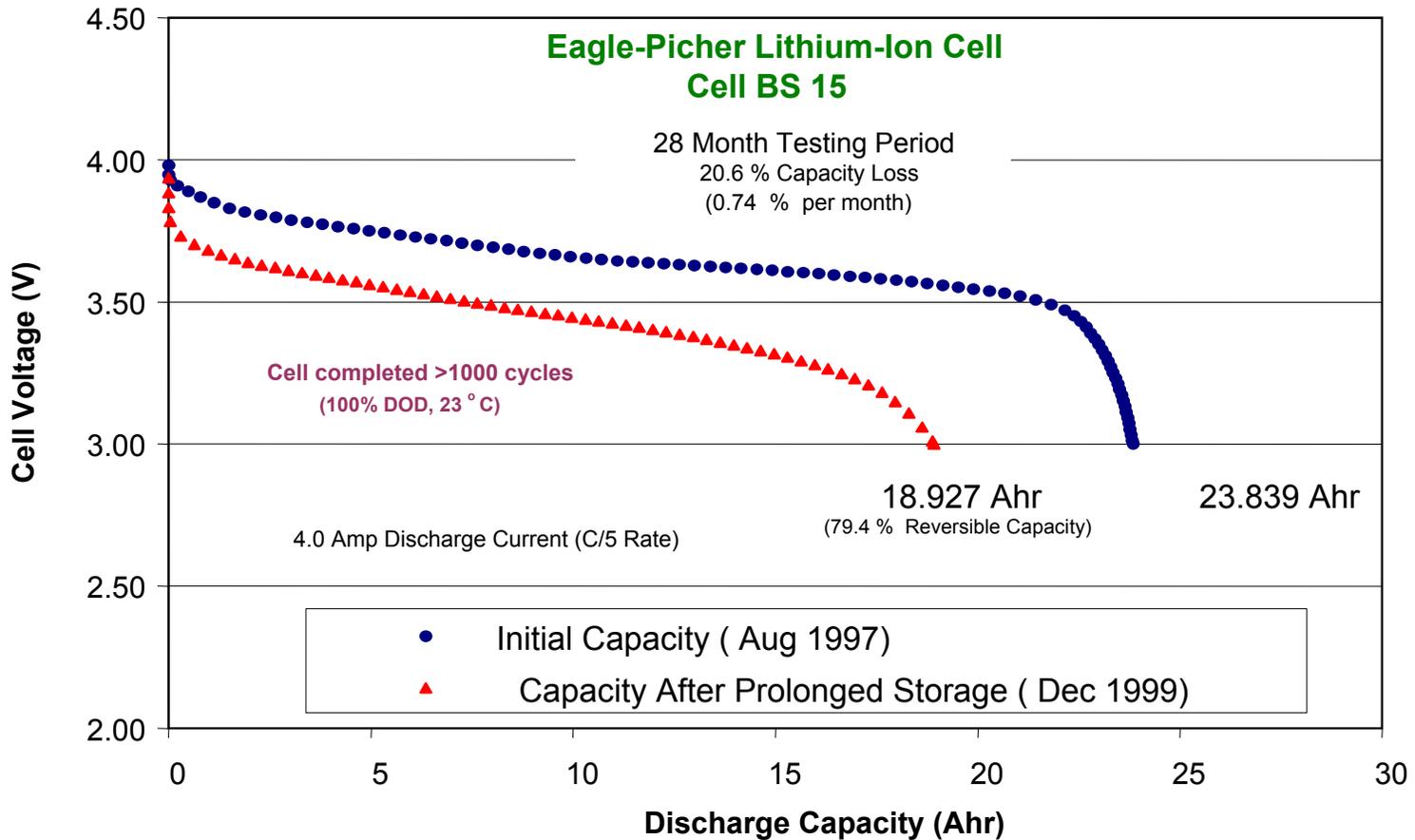
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# **Cell Cycling and Storage - Cycling at 100% DOD, C/5 at 23°C**

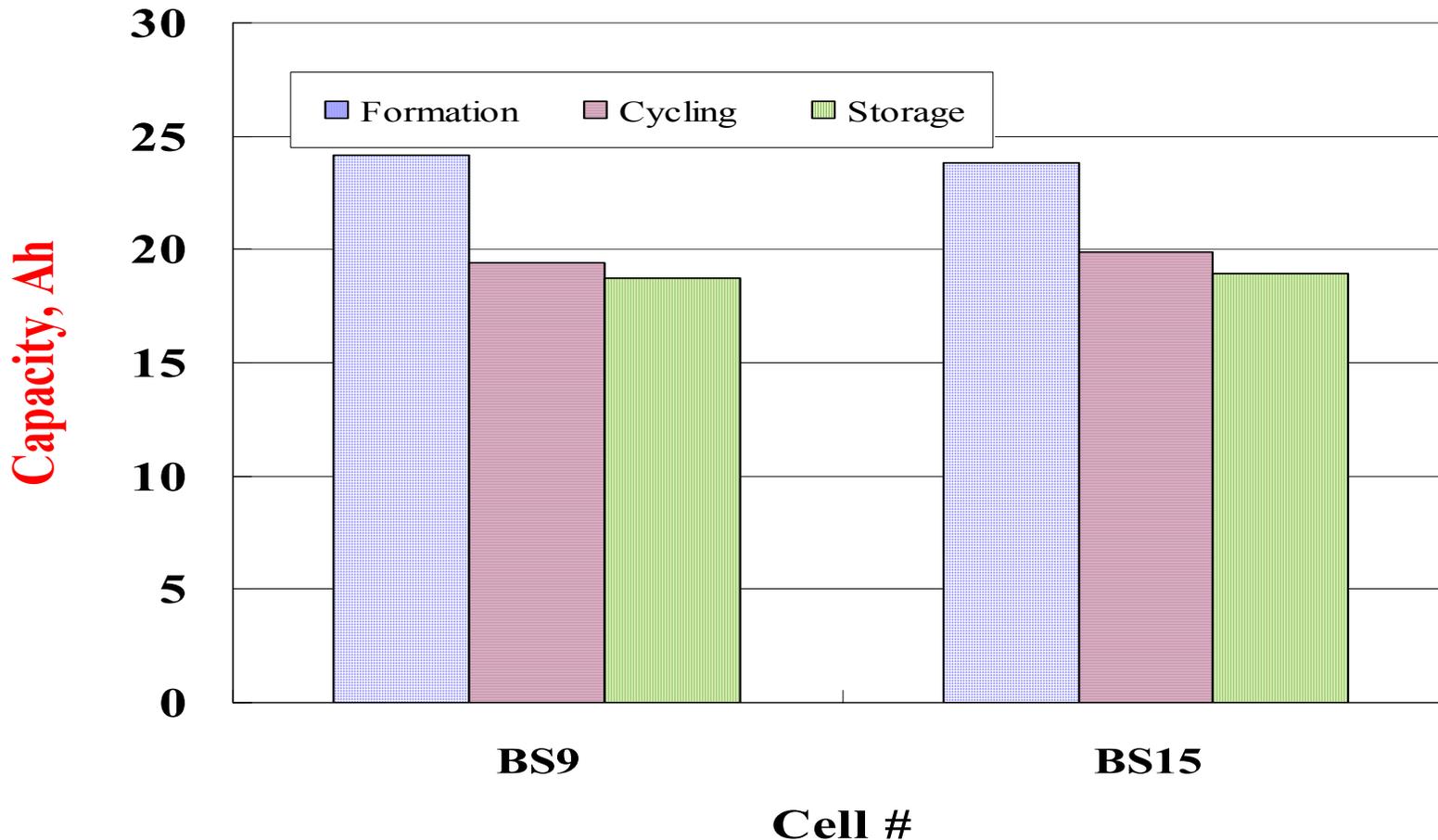
- **Cells cycled for 1000 cycles at 100% DOD, at RT before storage**
- **Cells stored at RT, probably at 100% SOC for about 1.5 years (18 months).**
- **Total storage (including the cycling time) since manufacture : > 30 months.**
- **Cells then placed back on 100% DOD, C/5 cycling for 1500 more cycles, approximately 2 years**

# EPEPC cell cycled and stored at RT



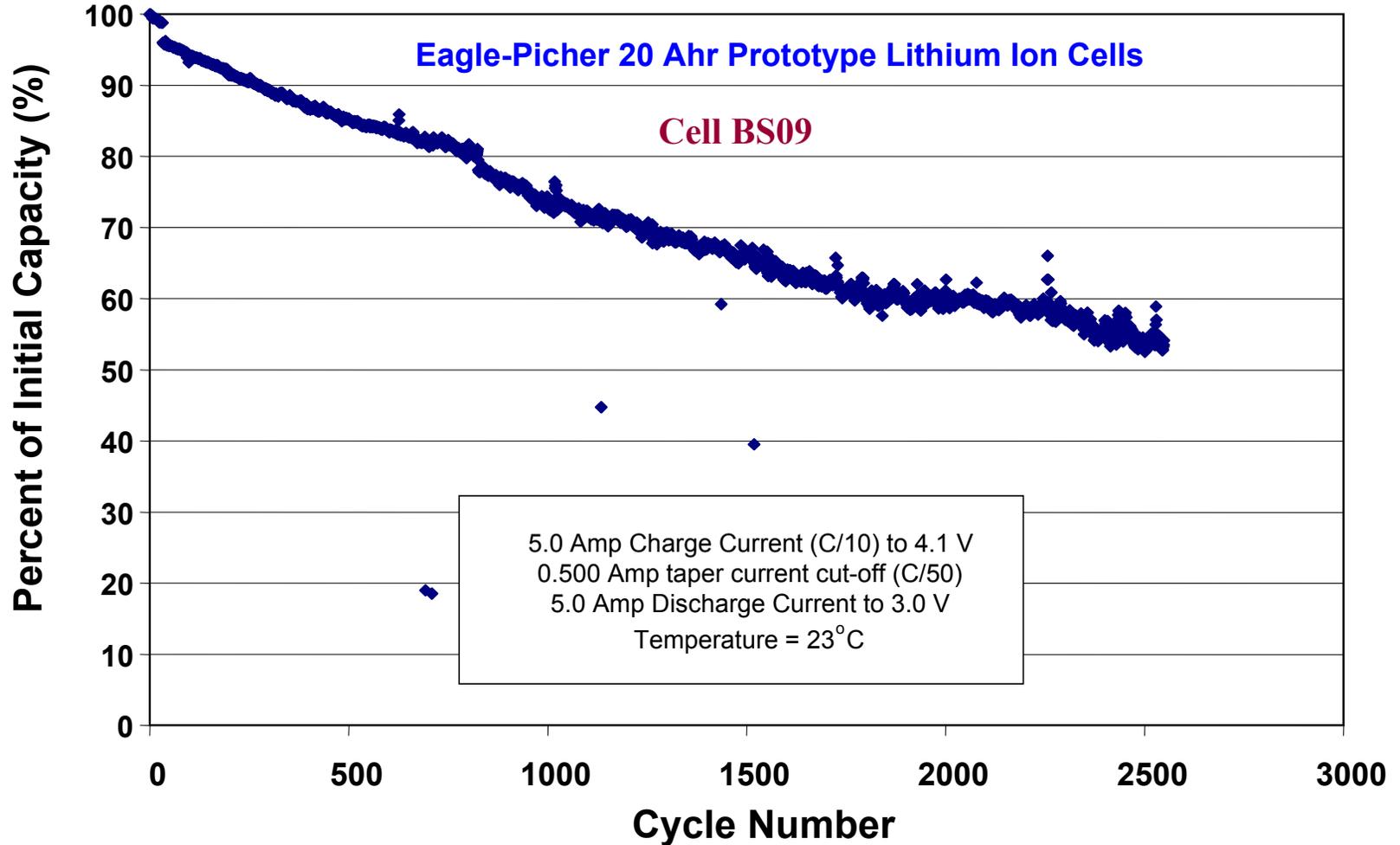


## Capacity Changes upon RT Cycling (100% DOD) and storage



- **17-20 % loss during cycling (1000 cycles over 500 days) and 3-4% loss during storage (1.5 years).**

## Cycle Life and Storage Performance (Gen I 20 Ahr), 4.5 years Testing

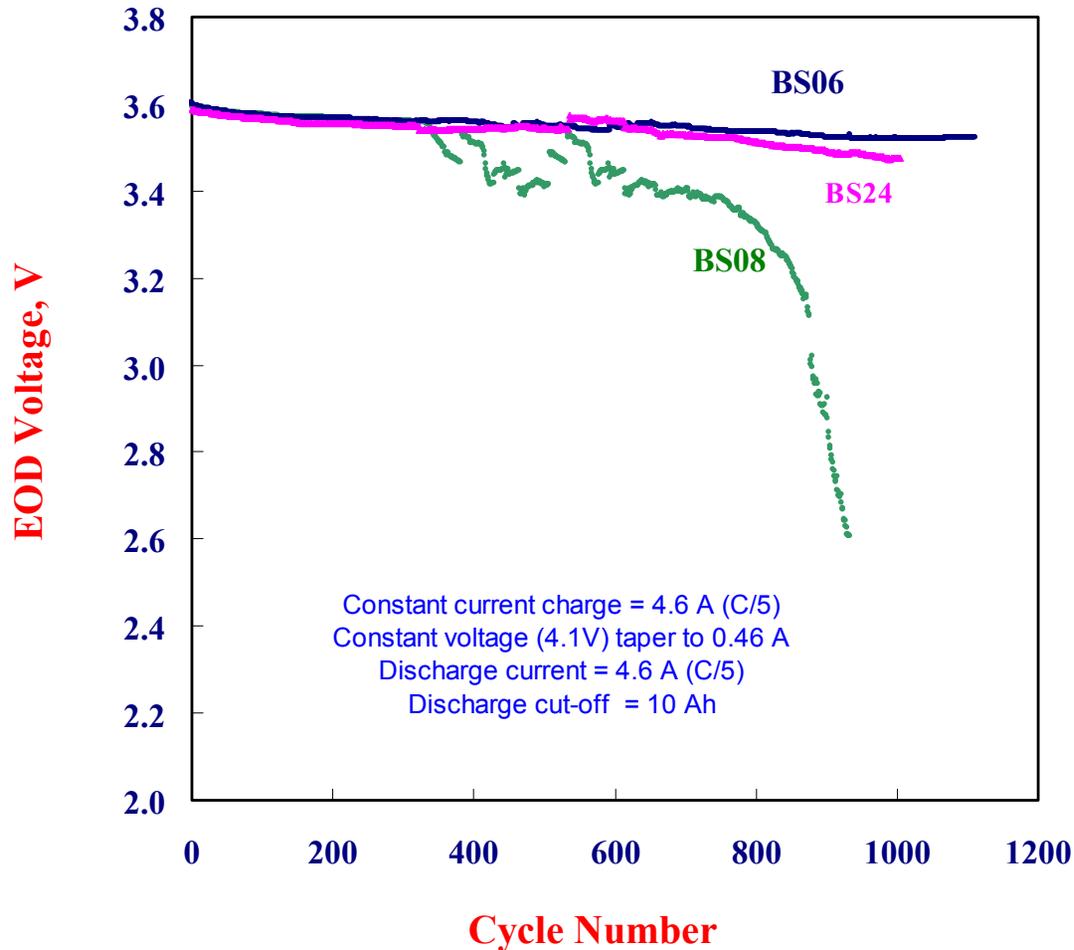


### **Cell Cycling and Storage - Cycling at 50% DOD at 0°C**

- **Cells cycled for 1000 cycles at 50% DOD and 0°C before storage**
- **Cells stored at 0°C, probably at 100% SOC for about 1.5 years (18 months) after cycling.**
- **Total storage (including the cycling time) since manufacture : > 30 months.**
- **Post storage tests in Jan-Feb. 00**
  - **Capacity check at RT**
- **Further storage at 0°C in progress**



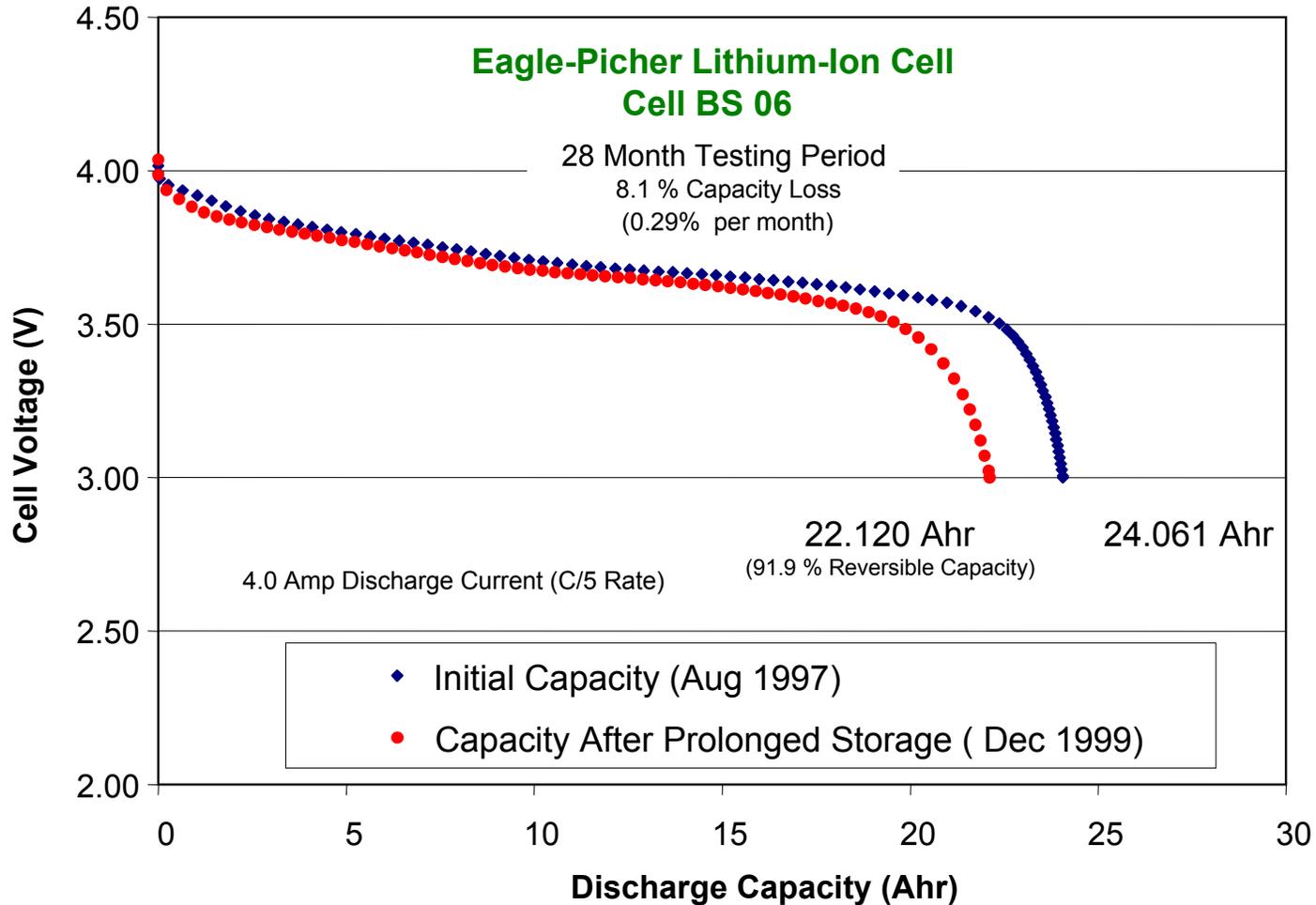
## Cell Cycling and Storage - Cycling at 50% DOD at 0°C



- End of discharge voltage depression : 7-8 mV/100cycles.

# 20 - Ah Cylindrical Cell

**Cycling at 50% DOD (1000 cycles) at 0°C then Stored at 0°C for 18 months**



### **Conclusions - Design I**

- The cycling results from the Design I cell were quite impressive with slightly greater than 50% of initial capacity after 2500 cycles at 23°C and 100% DOD, total test time approximately 4.5 years**
- Storage advantage of 0°C over RT is quite evident with only a 8% loss in capacity after 1000 cycles at 0°C and 18 months storage at 100% SOC versus 20% loss with 100% DOD and storage both at 23°C**



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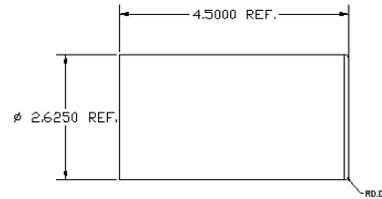
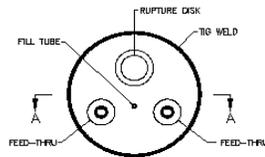
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## *Design Features*

- o Drawn Can - SS304**  
**2.625" diameter x 4.50" x 0.19"**
- o Standard Penetrations**  
**TA-23, 0.187" Ta - 4-40 thread**  
**Fill Tube, Rupture disc 150 psi**
- o Positive electrode, 639 x 8.80 x 0.017 cm (LiCoO<sub>2</sub>)**
- o Negative electrode, 656 x 9.10 x 0.011 cm**
- o Cells delivered September 1998**

# 25 - Ah Cylindrical Cell

## Cell Design - Design II

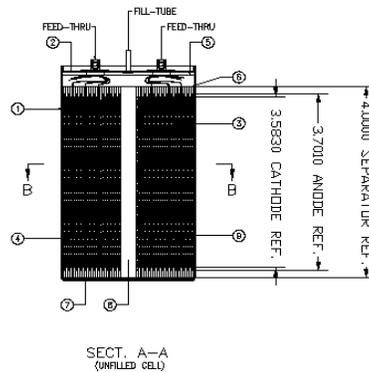


ITEM	QTY.	DESCRIPTION / DWG. NUMBER
1	1	CAN M044801
2	1	CAP ASSEMBLY M044803
3	1	CATHODE M044804
4	1	ANODE M044805
5	1	TOP INSULATOR M044806
6	1	JELLY ROLL INSULATOR M044807
7	1	BOTTOM INSULATOR M044808
8	*	ELECTROLYTE, 1MLIPF <sub>6</sub> EC/EMC
9	A/R	SEPARATOR, CELGARD 2300, 4.000" WIDE

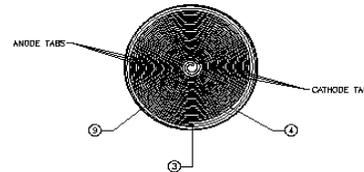
\* - ELECTROLYTE WEIGHT 200 ± 10g.



GENERAL VIEW



SECT. A-A  
(UNFILLED CELL)



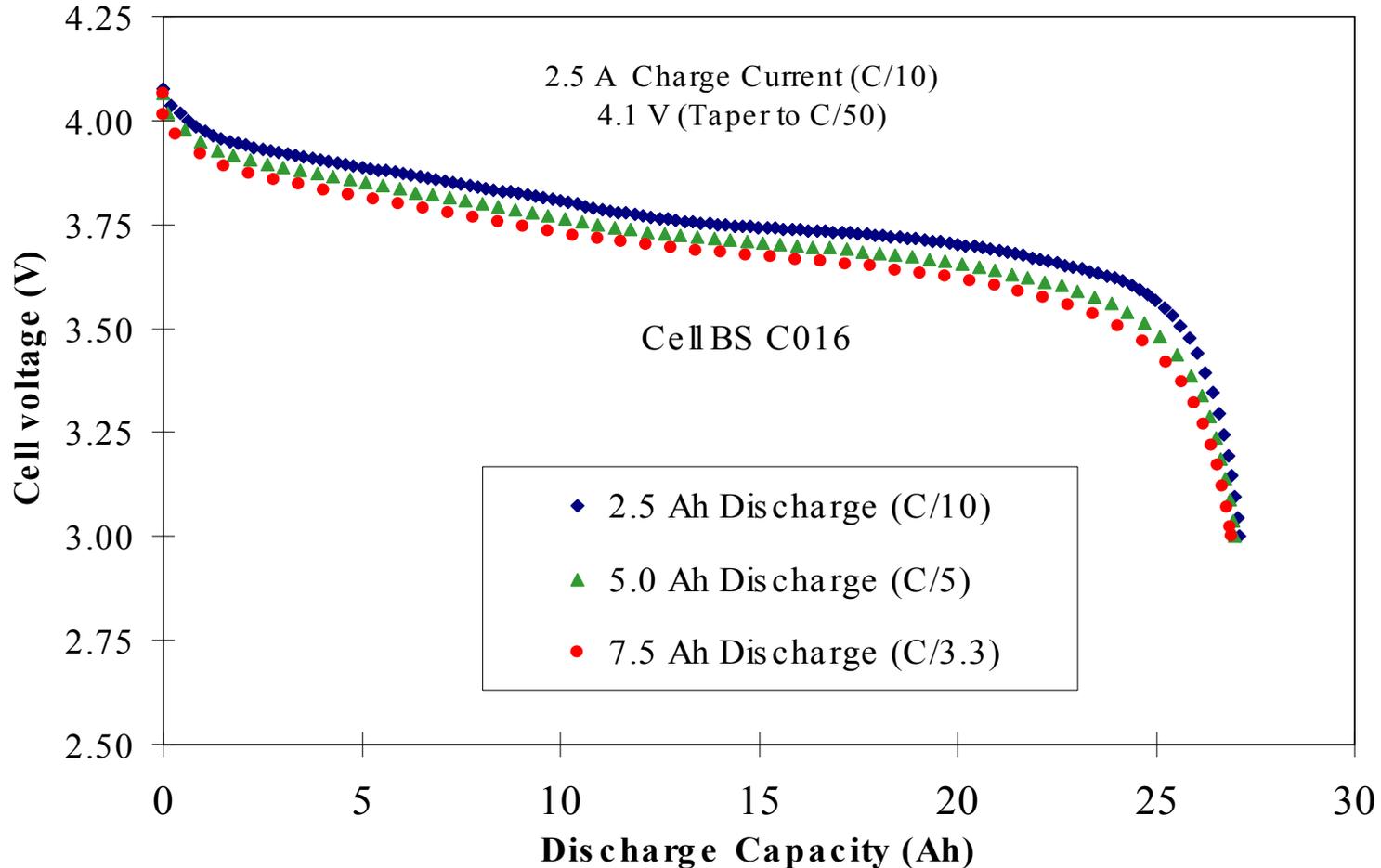
SECT. B-B REMOVED

NOTES:

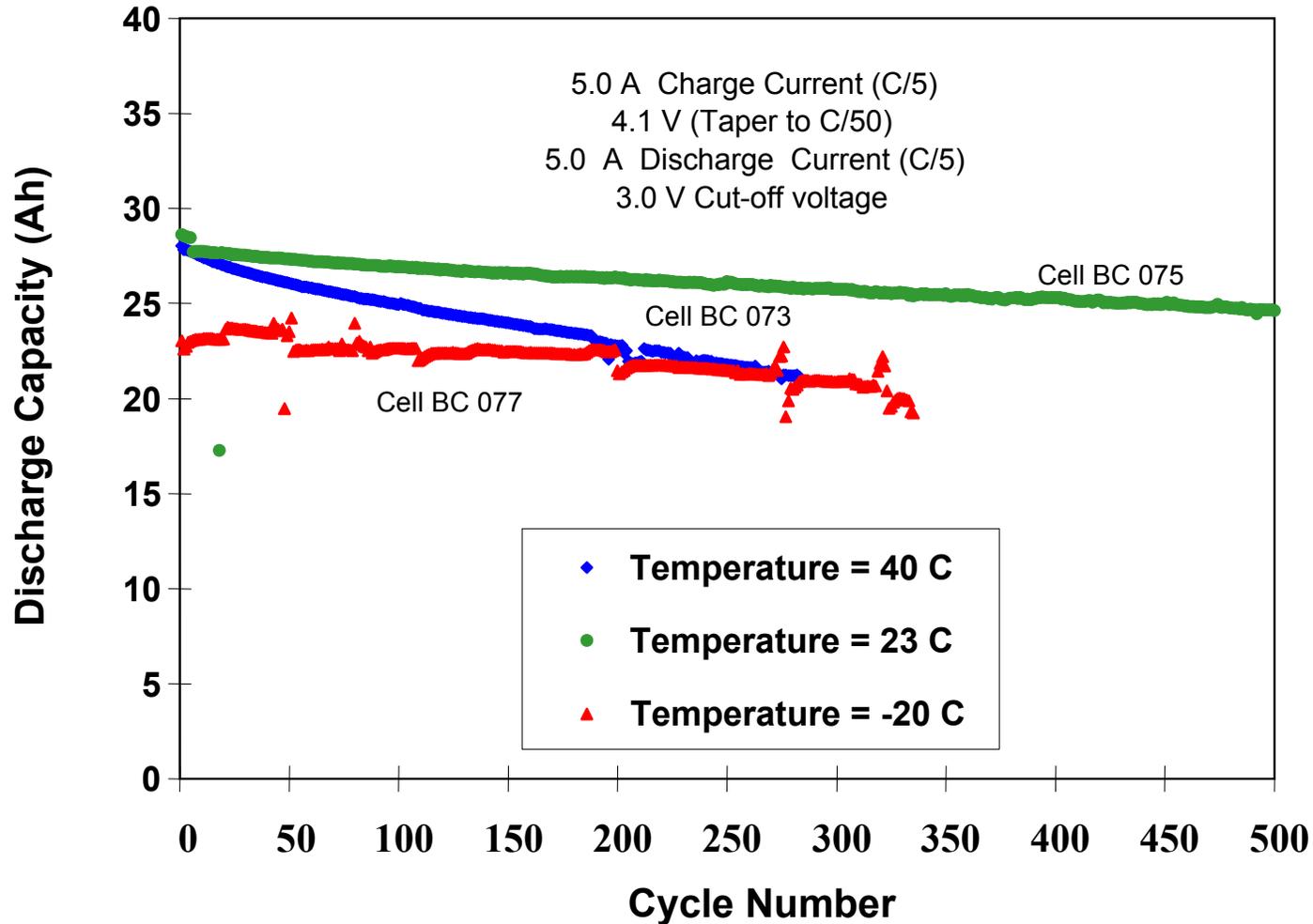
- UNFILLED CELLS TO HAVE A HERMETIC LEAK RATE LESS THAN 3 X 10<sup>-4</sup> STD. C.C./SEC. OF HELIUM.
- FILL TUBE TO BE SEALED WITH A PINCH, RESISTANCE WELD. END OF TUBE TO BE FLATTENED, TRIMMED TO 0.2±1 FROM TOP OF CAP, SEALED WITH A TIG WELD AND FOLDED OVER.

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	VANCOUVER, B.C.		
	TOLERANCES UNLESS OTHERWISE SPECIFIED		
	DIMENSIONS IN IN.	ANGLES +/- 1 DEGREE	.XX +/- .010
	SURFACE FINISH 125	FRACTIONS +/- 1/32	.XXX +/- .001
DATE:	67-1143 G.A.		D
SCALE:	DESIGN II 25Ah CYLINDRICAL		
DRAWN:			
CHECK:			
APPROVED:	DWG.#:M044800D		A

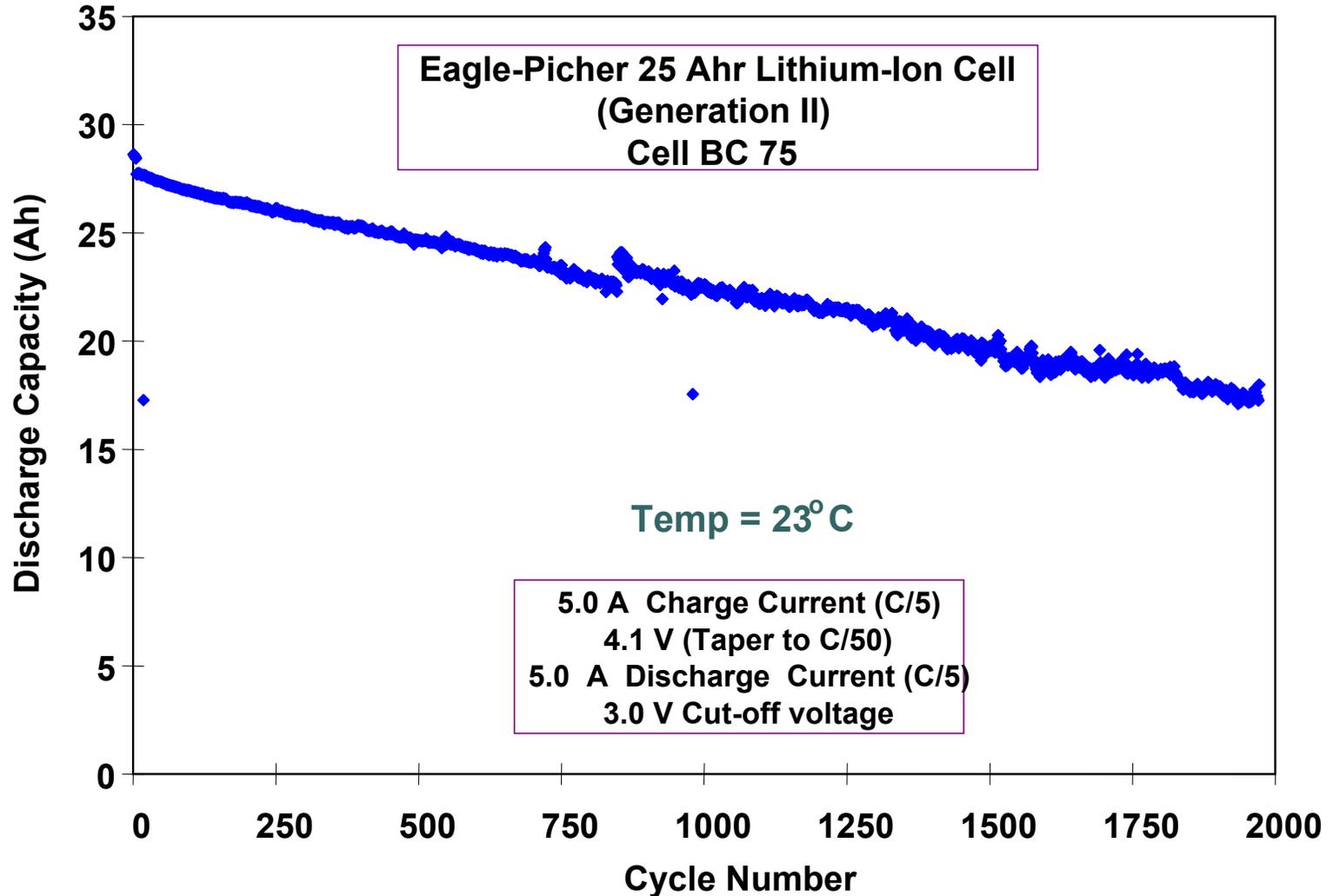
## Eagle-Picher 25 Ah Lithium - Ion Cells for Lander Applications Room Temperature Rate Capability



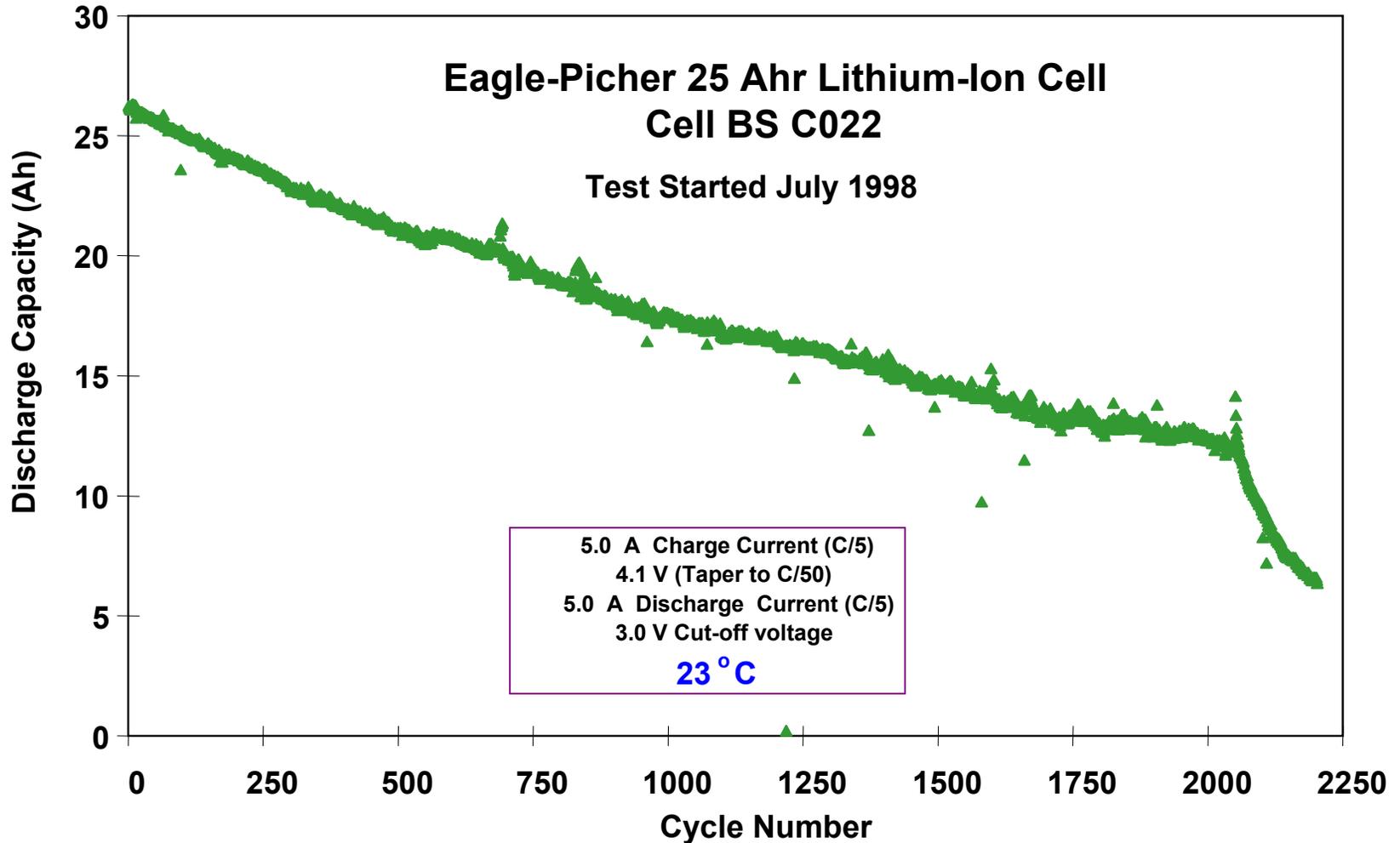
## Cycle Life Characteristics at Different Temperatures (Gen II)



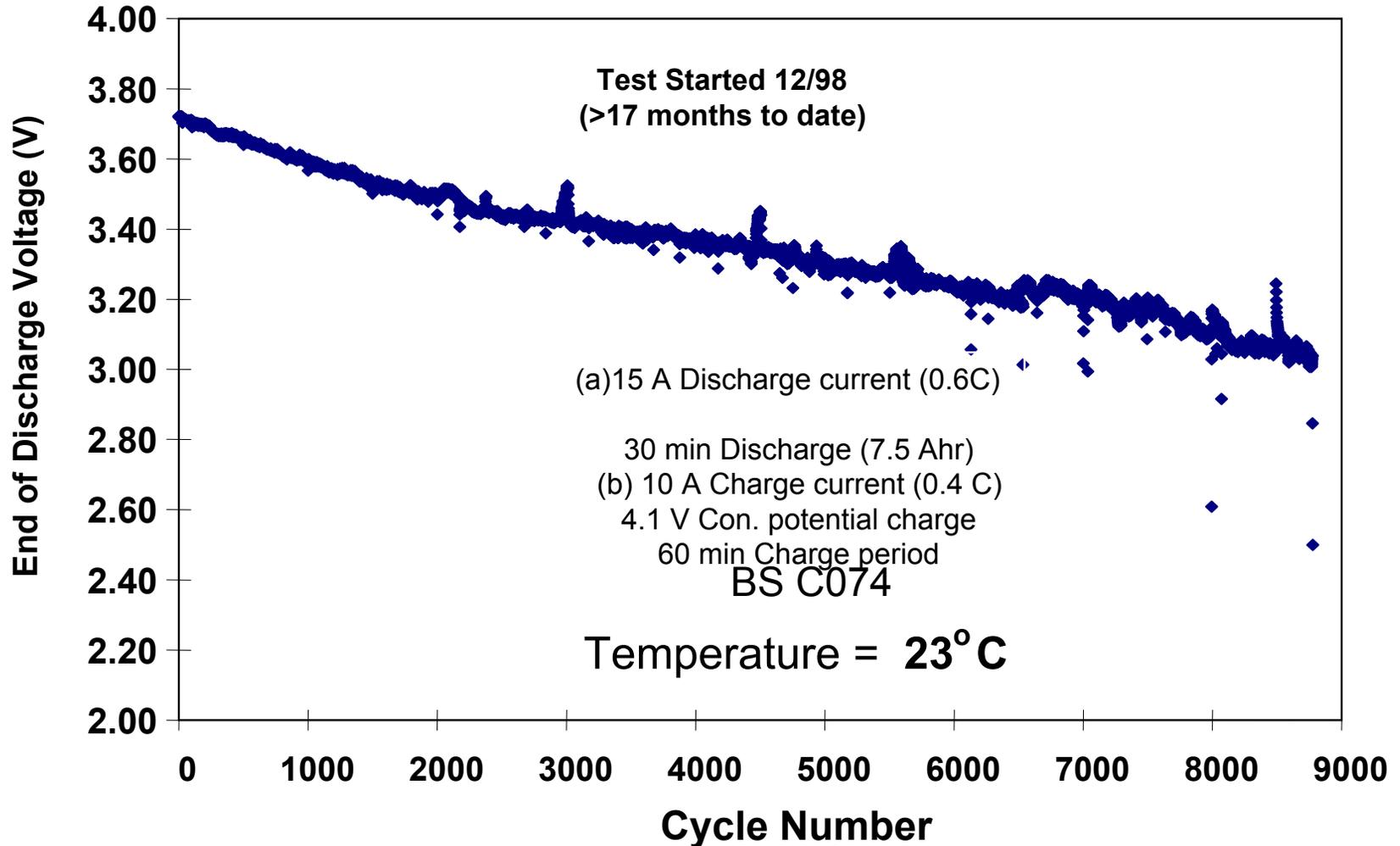
## Room Temperature Cycle Life Performance (100% DOD at 23°C)



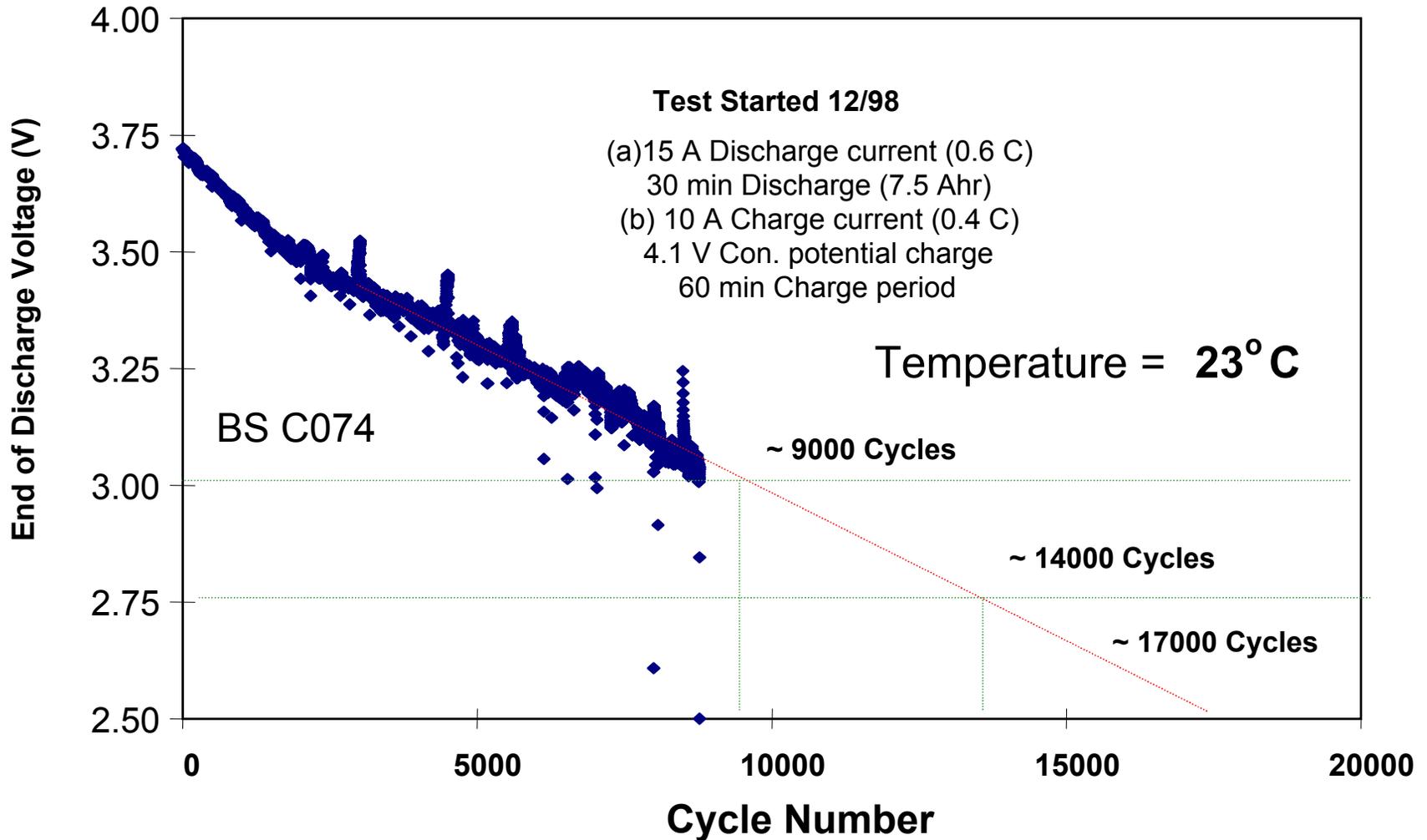
## Room Temperature Cycle Life Performance (100% DOD at 23°C)



## Eagle-Picher 25-Ah Cell - JPL LEO Test Results



## Eagle-Picher 25-Ah Cell - JPL LEO Test Results



### **Conclusions - Design II**

- **Design changes from Design I to II resulted in improved low temperature performance and rate capability**
- **Effect of temperature on capacity fade as expected**
- **Very good cycle life at 60% initial capacity at 2000, 100% DOD, C/5 cycles**
- **Simulated LEO test protocol, 30% DOD, shows 9000 cycles at 23°C. Better results would be expected at lower temperatures**
- **One cell vented after 2000 cycles with only a loss in capacity**

## **Conclusions - General**

- **One of the first large lithium ion cells delivered for evaluation**
- **Showed the potential for the technology to replace existing technologies and to be mission enabling**

## **Acknowledgements**

- EPEPC gratefully acknowledges the cooperation and test results provided by JPL.**